JOURNAL
OF
SOUTH AFRICAN BOTANY
VOL. XXV.

Published: OCTOBER, 1959

OBSERVATIONS ON THE DISTRIBUTION AND ECOLOGY OF ORCHIDACEAE IN THE MUIZENBERG MOUNTAINS, CAPE PENINSULA.

By A. V. HALL.

(*Botany Department, University of Cape Town.*)

I. INTRODUCTION.

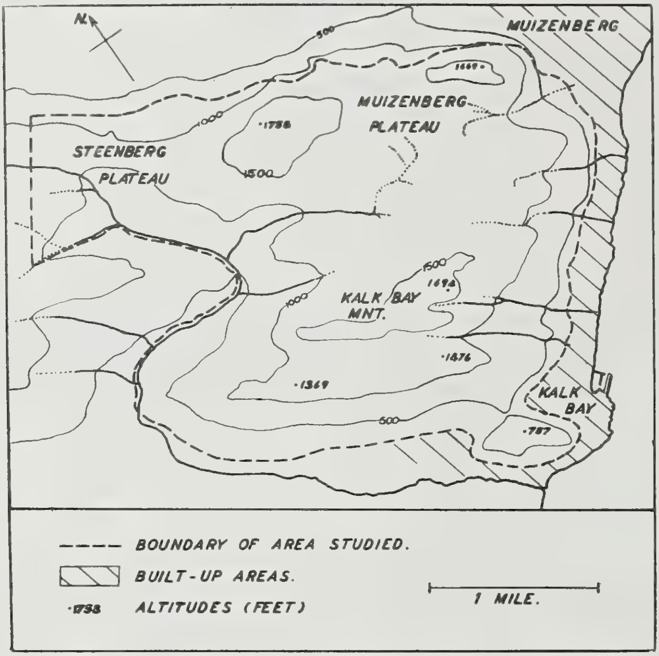
Ecological data on South African Orchidaceae is as yet rather fragmentary, being mostly in the form of notes on habitats of species in taxonomic monographs. An attempt is made in this paper to examine the relation between ecological factors and the distribution of orchids within a specified area.

The nomenclature used is according to Lewis' treatment in the Flora of the Cape Peninsula (1950).

TOPOGRAPHY AND SOILS.

The area selected for this investigation lies in a mountainous tract midway along the Cape Peninsula. A good deal of the area studied lies above 1,000 feet, with some points over 1,600 feet in altitude (Map. I). A relatively large proportion of the slopes face north-east and south-west, especially in steeper parts (Fig. 1). Very steep north-west slopes are rare.

Soils are typically sandy, predominantly derived from Table Mountain sandstone. Much of the terrain is rocky with boulder-strewn slopes and occasional broken cliffs. On south-facing slopes many of the ledges and soil-filled crevices in these cliffs are kept moist for the greater part of the year by seepage. Perennially moist soils are also found in parts of the two plateaux included in the area.



Map I.—Showing extent and topography of the area studied.

CLIMATE.

The Cape Peninsula lies in an area receiving rainfall in winter, a season in which north-westerly winds prevail. In summer, south-easterly winds cause mists to gather against higher slopes for periods of several days. The mists rarely descend below 800 feet above sea-level.

The early experiments of Marloth (1905) show that considerable amounts of moisture are deposited by these mists. However, Marloth's experiments were carried out near the summit of Table Mountain. As the highest points in the Muizenberg mountains are about 1,800 feet lower in altitude, dense mists which, according to Marloth, cause by far the greater amount of deposition, are rather less frequent.

Rainfall has been recorded at three places near the area under investigation (Table I).

TABLE I.

Rainfall near the Muizenberg Mountains.

Locality	Alt. (M.)	No. of years averaged.	Ann. av. (mm.).	Max. (mm.).	Min. (mm.).
Tokai, 1½ miles north of area	56	64	966·2	1586·2	590·3
Muizenberg reservoir at N.E. tip of area	91	44	1285·7	1954·0	867·2
Fish Hoek, ½ mile south of area	15	6	735·3	887·0	569·5

VEGETATION.

The vegetation is typical South-Western Cape sclerophyll, having a predominance of small-leaved shrubs and reed-like Restionaceae. Small patches of evergreen forest are found in sheltered kloofs. The vegetation has been subjected to intermittent burning for many years and as a result dense cover is uncommon.

II. DISTRIBUTION OF SPECIES.

RECORDING METHODS.

To obtain adequate distribution data, an area of five square miles was used. All localities were recorded as co-ordinates of a grid with units measuring 220 x 220 yards, drawn to scale on a 1 : 17,000 contour map of the area. Where local habitat variation was great the grid units were divided into 25 sub-units, with corresponding sub-co-ordinates.

Habitat notes were made at each locality where orchids were found, together with estimates of the number of plants present of each species. Locality and frequency data were later plotted on maps of the above scale to show the distribution of each species throughout the area.

Grid units were systematically examined at least twice during the flowering season. In addition, a large number of localities were known to the author before 1955, when the distribution patterns were plotted.

DISPERSAL.

The distribution data can be considered from two viewpoints: firstly, dispersal throughout a large area (Table II); and, secondly, dispersal within small units of the area (Table III).

TABLE II.

List of species in descending order of dispersal, based on the number of grid units occupied by a species. The number of observed individuals is appended for rare species.

Species.	*No. of grid units containing at least one individual.*
Satyrium bicorne (L.) Thunb.	101
Satyrium odorum Sond.	64
Disperis capensis (L.f.) Sw.	57
Holothrix villosa Lindl.	46
Pterygodium catholicum (L.) Sw.	45
Monadenia micrantha Lindl.	33
Liparis capensis Lindl.	28
Herschelia graminifolia (Ker.) Dur. & Sch.	25
Satyrium saxicolum Bolus	23
Holothrix condensata Sond.	22
Disa maculata L.f.	17
Holothrix squamulosa Lindl.	17
Penthea patens (L.f.) Lindl.	16
Satyrium bicallosum Thunb. var. ocellatum Bolus	13
Satyrium coriifolium Sw.	13
Acrolophia Bolusii Rolfe	13
Orthopenthea rosea (Lindl.) Rolfe	12
Disa glandulosa Burch.	11
Disa ferruginea (Thunb.) Sw.	11
Satyrium bracteatum (L.f.) Thunb.	10
Satyrium lupinulum Lindl.	9
Bartholina ethelae Bolus	8
Disa racemosa L.f.	7
Ommatodium volucris (L.f.) Lindl.	7
Disa cornuta (L.) Sw.	6
Acrolophia lamellata (Lindl.) Schltr. & Bolus	6
Satyrium carneum (Dry.) R. Br.	5
Disa cylindrica (Thunb.) Sw.	5
Schizodium sp.	5
Disa uniflora Berg.	3
Monadenia multiflora Sond.	3
Pterygodium acutifolium Lindl.	2
Satyrium bicallosum Thunb.	2

Species.	*No. of grid units containing at least one individual.*
Satyrium ochroleucum Bolus	2
Orthopenthea bivalvata (L.f.) Rolfe	1 (118 plants in 1955).
Monadenia reticulata (Bolus) Dur. & Sch.	1 (16)
Disperis bodkinii Bolus	1 (9)
Eulophia tabularis Bolus	1 (3)
Orthopenthea atricapilla (Harv.) Rolfe	1 (2)
Monadenia ophrydea Lindl.	1 (2)
Eulophia capensis (L.) Bolus	1 (2)
Ceratandra atrata (L.) Dur. & Sch.	1 (2)
Disperis paludosa Harv.	1 (1)
Forficaria graminifolia Lindl.	1 (1)

TABLE III.

Frequency of various densities of individuals.

Species.	Number of grid squares occupied at various density levels.					
	1—2 pl.	3—5 pl.	5—10 pl.	11—20 pl.	21—40 pl.	>40 pl.
Monadenia micrantha	27	3	3	—	—	—
Disa cornuta	5	1	—	—	—	—
Herschelia graminifolia	16	8	1	—	—	—
Disperis capensis	37	10	9	1	—	—
Disa ferruginea	6	4	1	—	—	—
Satyrium lupinulum	4	3	2	—	—	—
Satyrium bicorne	34	28	18	7	7	7
Satyrium coriifolium	4	2	4	2	1	—
Satyrium carneum	1	2	1	1	—	—
Holothrix squamulosa	2	5	7	3	—	—
Liparis capensis	4	3	10	4	3	4
Satyrium saxicolum	—	4	2	6	6	5
Satyrium odorum	—	8	13	19	10	14
Pterygodium catholicum	—	2	6	5	8	24
Holothrix condensata	—	—	3	3	4	12

It can be seen from Table II that few species are widely dispersed. Species found in less than five of a possible 324 grid units comprise 34 per cent of the total. While two of the 42 species had not been found before in the area, a further 16 species recorded by previous collectors were not seen.

An unexpected characteristic of local dispersal is demonstrated by Table III. Several species widely scattered throughout the area were often represented by only a few plants in each grid unit (e.g. *Herschelia graminifolia, Monadenia micrantha*). This type of distribution has been noted by collectors for *Disa cornuta*, which was not frequent enough in the area to illustrate this phenomenon clearly. Other species, notably *Satyrium odorum, Pterygodium catholicum* and *Holothrix condensata*, tend to be gregarious, whilst *Satyrium bicorne* and *Liparis capensis* are neither over- nor under-dispersed.

ASPECT AND ANGLE OF SLOPE.

At an early stage in preliminary studies, the author noticed relative absence of many species on north-facing slopes. This led to an examination of the relationship between distribution and aspect.

The frequency of various species on different aspects is illustrated in Fig. 1. Lines radiating from the centre of each diagram show by their length the relative numbers of records of a species on various aspects. The frequency of slopes with such aspects is represented by an outline surrounding each diagram. Diagrams are presented for three classes of angle of slope.

Data for the diagrams was compiled from a 1 : 25,000 Trig. Survey Map of the Cape Peninsula. A grid with units representing 220 x 220 yards was laid over the map and in each unit the mean aspect and distance between contours was estimated. Each aspect value was listed in one of three tables, depending on whether the accompanying figure for distance between contours corresponded to an angle of slope class of 0°—10°, 10°—30°, or more than 30° from the horizontal. Within the angle of slope classes, the number of aspect values lying in each 20° sector of the compass was found and plotted on a radial chart. The resulting points were linked up to form the outlines of the diagrams, which thus show the approximate relative frequency of various aspects, within specified ranges of angle of slope. In the case of steeper slopes, no allowance was made for the fact that the surface area of a steep slope is diminished on its horizontal projection in a map.

A similar method was used to plot orchid localities, although field observations were used in places of great local variation in aspect. The number of plants in each slope class is shown next to the diagrams. With one exception, data is only presented for widely dispersed species. There was no exceptional behaviour among the less frequent species not represented in Fig. 1.

With the majority of species little response to aspect is shown on 0—10° slopes. Preference for south-facing slopes becomes apparent at 10°—30°, whilst in places steeper than this, many species are completely

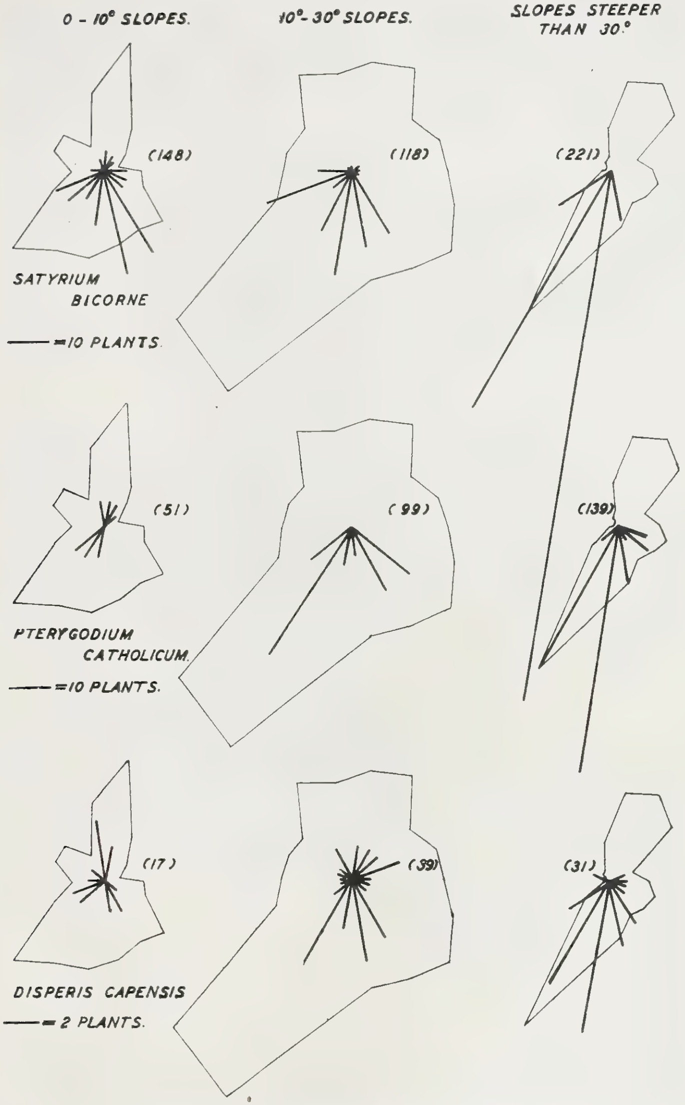


Fig. 1.—Diagrams to show the distribution of flowering individuals and colonies on various aspects and angles of slope. Aspects directly above the centre of each diagram face due north.
For further explanation, see text.

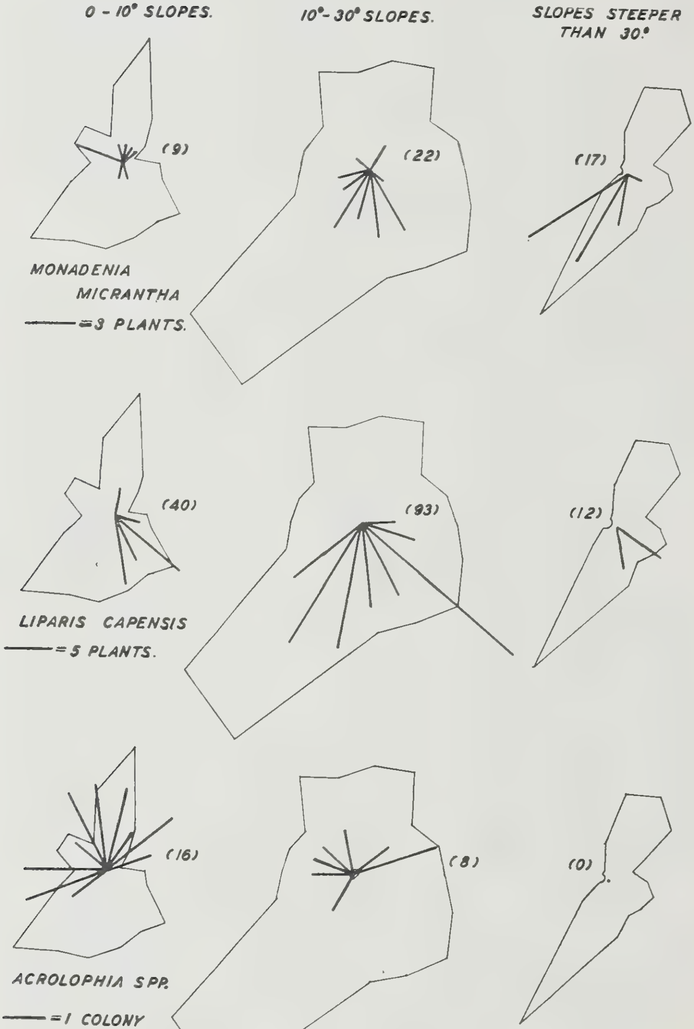


Fig. 1.—*Continued.*

excluded from slopes with the slightest north-facing aspect (e.g. *Satyrium bicorne*, *Pterygodium catholicum*, *Monadenia micrantha*). *Disperis capensis* shows greater ability to inhabit northerly aspects than the other species, especially on 10°—30° slopes. *Acrolophia spp.* appear indifferent to aspect on moderate slopes.

ALTITUDINAL RANGE.

The altitudinal range of the most widely distributed species is shown in Fig. 2. Late summer-flowering species (*Disa ferruginea*, *Herschelia graminifolia*) and the early winter-flowering *Liparis capensis* are restricted to high elevations. In addition, species that inhabit moist ledges and crevices in cliffs (*Orthopenthea rosea*, *Disa maculata*) were not found in such places at low altitude.

POST-BURNING PERIOD.

A number of authors have recorded increased activity of geophytes after fires (Adamson 1935, Michell 1922, Wicht 1949). This effect was noticed in preliminary surveys.

Accordingly, to obtain general information on immediate and long-term effects of fires, a map was prepared showing when each part of the area had been last burnt, for comparison with orchid distribution patterns.

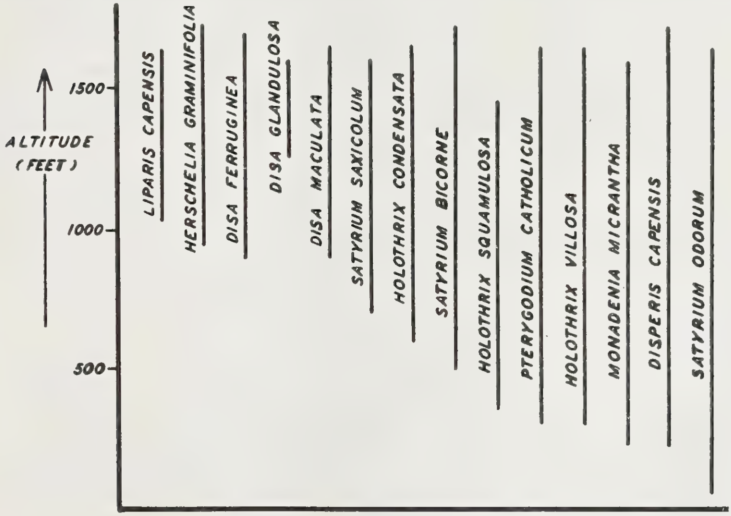


FIG. 2.—To show the altitudinal range of various species.

The approximate post-burning period was obtained by counting the number of annual zones of rapid growth on stems of certain shrubs. The zones were most clearly shown by members of the genus *Leucadendron* (Proteaceae), where they could be identified by lack of branching and wider spacing of leaf bases. The species used are destroyed by fire and regenerate from seed in the following spring. This method has proved reasonably reliable when tested on burnt areas of known age.

Frequencies of the more widespread species in veld of various ages are presented in Table IV.

TABLE IV.

Average number of plants or colonies in flower per square $\frac{1}{4}$ mile of veld of various ages.

Period since last fire occurred (years).	0—1	2—4	5—10	>10
Satyrium bicorne	80	7	8	3
Pterygodium catholicum	17	3	1	1
Monadenia micrantha	4	1	r*	r
Disperis capensis	—	r	r	1
Herschelia graminifolia	—	r	r	1
Satyrium odorum (colonies)	r	—	1	5

* r=rare.

While many other factors probably affect these results, frequencies in the first year after burning appear significantly high for the first three species. Results for the last three species showing lower frequencies in recently burnt areas may also be significant.

In addition to this more general method, detailed observations were made for five years on part of a burnt firebelt on the Muizenberg plateau. The firebelt consists of three adjacent 25-yard-wide strips of veld, each strip being burnt once every three or four years. Thirty-yard lengths of two such intermittently burnt strips were kept under observation, together with adjoining veld which had not been burnt for at least 10 years.

The stretch of firebelt studied passes from a dry sandy rise down into a zone which remains moist for the greater part of the year, being interlaced with streamlets in winter. Strip I of the firebelt was burnt in midwinter 1954, Strip II a year later. Strip I was burnt again in the autumn of 1958. Numbered stakes were used to indicate the positions of individual plants. Results are shown in Table V.

Monadenia micrantha and *Satyrium bicorne* did not show an excessive increase in numbers after fire, a result which is in contrast to data from other parts of the Muizenberg mountains (Table IV). *Orthopenthea bivalvata* and *Disa obtusa*, however, showed a very clear increase in numbers on both strips in the second season after burning. In the third season no trace of the plants could be found, and in the fourth season careful excavation of the staked sites did not reveal dormant tubers. Similar results were recorded for other species that appeared mostly on Strip I. As absence of aerial parts in the third season on Strip I coincided with the occurrence of large numbers of healthy plants of the same species on Strip II, it does not seem likely that the cycle could be a direct result of year-to-year variation of a factor such as rainfall.

TABLE V.

Numbers of flowering individuals occurring at various periods after fires in a small area on Muizenberg plateau.

Zone	Dry veld in Strips I and II					Moist veld in Strip I					Moist veld in Strip II					Unburnt veld				
Approximate period since last fire, at time of flowering (years)						0·5	1·5	2·5	3·5	0·5	3·5	0·5	1·5	2·5	3·5	>10				
Year in which flowering season began	1954	1955	1956	1957	1958	1954	1955	1956	1957	1958	1954	1955	1956	1957	1958	1954	1955	1956	1957	1958
Monadenia micrantha	1	2	2	–	–	1	2	3	3	–	–	–	–	–	–	All species absent.				
Satyrium bicorne	1	1	1	–	–	–	–	–	–	–	–	3	3	2	3					
Orthopenthea bivalvata	–	–	–	–	–	–	115	–	–	–	–	3	12	–	–					
Disa obtusa	–	–	–	–	–	5	5	–	–	–	–	–	22	–	–					
Disa ophrydea	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–					
Penthea patens	–	–	–	–	–	–	3	–	–	–	–	–	4	–	–					
Disa cornuta	–	–	–	–	–	–	2	–	–	–	–	–	1	–	–					
Eulophia tabularis	–	–	–	–	–	–	3	2	–	–	–	–	–	–	–					
Orthopenthea atricapilla	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–					
Ceratandra atrata	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–					

Six of the 10 species recorded after the fire had not been encountered previously on the Muizenberg mountains. In contrast, no orchids were found in veld adjacent to Strip II that had been left unburnt for at least 10 years. Very few species were seen on the dry sandy rise in Strips I and II.

SOIL MOISTURE.

Soils in the area studied were predominantly dry in summer, although certain places remained moist for the greater part of the year. The distinctive orchid flora found in these places is listed in Table VI.

TABLE VI.

Species restricted to moist habitats.

Moist flats.	Moist rock crevices and ledges.
Disa racemosa	
Orthopenthea bivalvata	Disa uniflora
Orthopenthea atricapilla	Disa maculata
Disa obtusa	Disa glandulosa
Schizodium sp.	Orthopenthea rosea
Monadenia ophrydea	Satyrium saxicolum
Penthea patens	
Disperis paludosa	
Eulophia tabularis	
Ceratandra atrata	

III. DISCUSSION AND CONCLUSIONS.

A notable characteristic of the orchid distribution patterns is the localization and rarity of a large percentage of the species. In many cases this rarity can be traced to the influence of factors such as fire and soil moisture, while for other rare species the relationship between distribution and ecological data is obscure.

An illustration of the connection between rarity and occurrence of special local conditions is provided by the sudden appearance, and subsequent total disappearance, of previously unrecorded species on the moist burnt stretch of firebelt discussed in the section on fire. This firebelt is situated on the Muizenberg plateau, where a number of similar moist places exist, that had not been burnt for periods of eight to about 20 years. If these places were swept by fire it seems possible that other species would come to light, among them some of those recorded from the area by previous collectors but not found there by the author.

A difficult feature of distribution to understand is the lack of local aggregation of certain widely dispersed species, notably *Monadenia micrantha*. This species almost invariably sets seed from all its flowers and does not appear to have unusual edaphic or climatic requirements. An investigation of seed fertility and germination may lead to an answer to this problem.

An interesting feature is the restriction to high altitude of late summer- and autumn-flowering species. The chief difference between low and high altitudes, apart from possibilities of rainfall variation, lies in the occurrence of damp mists in the dry summer months above about 800 feet. Similar results were recorded by Curtis (1947) in Haiti, where 150 of the 195 species of orchids found on the island were restricted to high elevations where mists were frequent.

The majority of species show a preference for south-facing slopes. North-facing slopes with greater insolation and correspondingly greater evapo-transpiration could be a less favourable habitat for herbaceous orchids. Two xeromorphic species of the genus *Acrolophia*, however, showed indifference to aspect on moderate slopes. Species with a marked response to aspect (*Pterygodium catholicum*, *Satyrium bicorne*) tend to show higher frequencies than other species on steep slopes. This is in contrast to the two *Acrolophia* species which were not found at all in very steep places. Somewhat intermediate behaviour is shown by *Disperis capensis* (Fig. 1).

Factors responsible for the sometimes rapid increase in numbers of flowering individuals after a fire are obscure, and critical experiments are needed for their elucidation. It is not yet clear whether the effect is due to stimulation of tubers present in a vegetative state at the time of fire, or whether burning provides particularly suitable conditions for germination of seed blown from elsewhere after the fire. In this connection, it is interesting to note that some species showed increased activity in the first (Table IV) and others in the second flowering season following a fire (Table V).

IV. SUMMARY.

1. Distribution patterns of 44 species of the family Orchidaceae were examined in a five-square-mile tract of mountains on the Cape Peninsula, South Africa.

2. A grid map was used in a systematic examination of the area, in which frequency and density of individuals of each species were recorded. A large percentage of the species were strongly localized in the area, in contrast to others that were widely dispersed but not frequent in any one locality.

3. Relationships between the distribution patterns and various ecological factors were examined as follows:

(*a*) Aspect and angle of slope data was presented in radial aspect diagrams. Herbaceous species showed a preference for south-

facing slopes, whilst two xeromorphic species showed indifference to aspect on moderate slopes. Species with a marked response to aspect showed higher frequencies on very steep south-facing slopes than elsewhere.

(*b*) A study of altitudinal range revealed that late summer-flowering species were restricted to high elevations. The possible correlation between this distribution and the occurrence of summer mists is discussed.

(*c*) An examination of post-burning periods in the area in relation to distribution revealed a marked increase in numbers of flowering individuals of certain species after fire. In addition, results are presented of five years of observations on a stretch of burnt firebelt and an adjacent unburnt area. The implications of these results are discussed.

(*d*) Species only found in certain moist habitats are enumerated.

ACKNOWLEDGMENTS.

The author would like to thank Dr. E. A. Schelpe of the Botany Department, University of Cape Town, for his advice and most helpful criticism in the preparation of this work.

REFERENCES.

ADAMSON, R. S. 1935: The Plant Communities of Table Mountain, III: A six years' study of regeneration after burning. *Journ. Ecol.* XXIII, 44–45.

ADAMSON, R. S. and SALTER, T. M. 1950: *Flora of the Cape Peninsula.*

CURTIS, J. T. 1947: Ecological Observations on the Orchids of Haiti. *Amer. Orchid Soc.*, Bull. XVI, 263–269.

MARLOTH, R. 1905: Results of further experiments on Table Mountain for ascertaining the amount of moisture deposited from the south-east clouds. *Trans. S. Afr. Phil. Soc.*, XVI, 97–105.

MICHELL, M. R. 1922: Some observations on the effects of a bush fire on the vegetation of Signal Hill. *Trans. Roy. Soc. S. Afr.* X, 213–232.

UNION OF SOUTH AFRICA WEATHER BUREAU, 1950: *Climate of South Africa, Part* 2. *Rainfall Statistics.* Pretoria.

WICHT, C. L. 1948: A statistically designed experiment to test the effects of burning on a sclerophyll scrub community. I, Preliminary account. *Trans. Roy. Soc. S. Afr.* XXXI, 479–501.